

To: Betty Taylor[bttaylor@crcao.org]; Anderson, James (J.E.)[jander63@ford.com]; Camobreco, Vincent[Camobreco.Vincent@epa.gov]; Cooper, Geoff[GCooper@ethanolrfa.org]; Courtis, John[jcourtis@arb.ca.gov]; DeCicco, John M.[DeCicco@umich.edu]; Duffield, James[jduffield@oce.usda.gov]; Duncan, Marvin[mduncan@oce.usda.gov]; Farenback-Brateman, Jeff[j.h.farenback-brateman@exxonmobil.com]; H. Chul Kim[hkim41@ford.com]; Heirigs, Phil[phez@chevron.com]; Katzenstein, Aaron[AKatzenstein@aqmd.gov]; Larson, Robert[larson.robert@epa.gov]; Lax, David [lax@api.org]; Maclean, Heather[hmaclean@ecf.utoronto.ca]; Marelli, Luisa[luisa.marelli@jrc.ec.europa.eu]; Martin, Jeremy I.[JMartin@ucsusa.org]; McCormack, Derek[Derek.McCormack@NRCan-RNCan.gc.ca]; Natarajan, Mani[mnatarajan@marathonpetroleum.com]; Rose, Ken[ken.rose@concawe.org]; Wang, Michael Quanlu[mqwang@anl.gov]
Cc: Brent Bailey[bkbailey@crcao.org]; Jan Tucker[Jantucker@crcao.org]; Chris Tennant[ctennant@crcao.org]
From: Don Scott
Sent: Mon 6/17/2013 5:18:47 PM
Subject: Michigan State ILUC paper
[An alternative approach to indirect land use change Allocating greenhouse....pdf](#)

Someone asked for this on the call today. Attached is a 2012 paper from Seungdo Kim, Bruce Dale, and Rebecca Ong proposing an alternative approach to allocating indirect land use change.

Indirect land use change (iLUC) is hypothesized to occur when increasing demand for land

due to bioenergy production displaces food and feed production onto new lands, thereby

potentially producing large greenhouse gas emissions (GHG) during the land conversion

event. Thus far, the totality of the projected iLUC effect has been assigned to biofuel production. In fact, multiple drivers of land use change exist and the resulting GHG releases should, in fairness, be allocated among these drivers. It seems more useful and

intellectually rigorous to allocate potential land use change effects among these many drivers. This paper focuses on how to allocate the environmental consequences of iLUC to

the multiple drivers through a function-oriented approach, namely human nutritional requirements for calories and protein. "Food versus Biofuel" issues can then be more

usefully addressed as "Nutrition versus Biofuel" issues. Human beings actually have many choices in how we provide ourselves with adequate diets, and these choices have very different GHG and land use consequences. Therefore, in this paper, GHG assigned to iLUC is allocated between ethanol and human dietary preferences via a human nutrition-based method. Applying allocation approaches to iLUC lowers the estimated GHG of iLUC by up to 73% compared to GHG estimates in the GTAP model. For example, global warming intensity (GWI) of ethanol measured as CO2 equivalent becomes 58.2 g MJ₋₁, while GWI of ethanol calculated using GREET is 68.9 g MJ₋₁.

From: Betty Taylor [mailto:btaylor@crcao.org]

Sent: Friday, June 14, 2013 3:10 PM

To: Anderson, James (J.E.); Camobreco, Vincent; Cooper, Geoff; Courtis, John; DeCicco, John M.; Duffield, James; Duncan, Marvin; Farenback-Brateman, Jeff; H. Chul Kim; Heirigs, Phil; Katzenstein, Aaron; Larson, Robert; Lax, David; Maclean, Heather; Marelli, Luisa; Martin, Jeremy I.; McCormack, Derek; Natarajan, Mani; Rose, Ken; Don Scott; Wang, Michael Quanlu

Cc: Brent Bailey; Jan Tucker; Chris Tennant

Subject: REMINDER: 2013 CRC LCA Organizing Committee Teleconference Mon. June 17 at 11AM Eastern

Dear LCA Organizing Committee Members,

Just a reminder, our next call is on **Monday, June 17th at 11 AM ET**. I have attached the call agenda and the updated workshop agenda.

Please use the following to access the call:

U.S. and Canada: passcode:

Ex. 6

International:

passcode:

EX-6

If you have any questions, please let me know.

Best regards,

Betty Taylor

CRC Correspondence (not for public distribution)

COORDINATING RESEARCH COUNCIL, INC.

3650 MANSELL ROAD, SUITE 140

ALPHARETTA, GA 30022

TEL: 678/795-0506 ext.103 FAX: 678/795-0509

WWW.CRCAO.ORG

To: Larson, Robert[larson.robert@epa.gov]
From: Jim Greenwood, BIO President & CEO
Sent: Wed 5/6/2015 5:21:39 PM
Subject: Looking forward to meeting you in Philadelphia

Dear Larson,

It's been an incredible and important year for our industry and I want to thank you for being a part of it. During the upcoming [2015 BIO International Convention](#), June 15 - 18 in Philadelphia, I will update you on our progress this year and invite you to join me in addressing areas of future opportunity. Each year I relish the chance to speak with so many of you during the Convention, it is that dialogue and the connections we all make there that help drive our industry forward.

The [agenda](#) we have developed for BIO 2015 is an opportunity to dive deep into the most pressing issues we face and to hear from thought leaders, policy makers and visionaries. It is a chance to make the connections using our [One-on-One Partnering™ System](#) that can change the course of your business. One of the reasons we chose Philadelphia is the strength of the northeast region's biotechnology ecosystem—not only in Pennsylvania, but also in New Jersey, Delaware, New York, and Massachusetts. This region is ripe with opportunity and will host 2,500 CEO's and 15,000 leaders next month. [View our attendee list and event brochure here.](#)

At this year's Convention, we also will be honoring the [everyday superheroes of biotechnology](#). The men and women whose actions may not always make headlines, but who every day put in the hard work needed to move our industry forward in the lab, in our communities and in the halls of government. I hope you'll use this year's Convention as an opportunity to reach out to your industry peers, listen to their stories and share your own. While the paths that brought us all together may be dramatically different, many of the goals we have for our industry are the same.

As Christopher Reeve, a man who embodied the role of Superman on and off the screen, said, "So many of our dreams at first seem impossible, then they seem improbable, and then, when we summon the will, they soon become inevitable."

There is strength in numbers and what we can accomplish together is much greater than what we can accomplish on our own. Please join me next month in Philadelphia for BIO 2015. You may [visit this link](#) to register today.

Sincerely,

Jim

James C. Greenwood
President & CEO
Biotechnology Industry Organization (BIO)
1201 Maryland Avenue SW, Suite 900
Washington, DC 20024
202.962.6655

This message was intended for: larson.robert@epa.gov
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To: Larson, Robert[larson.robert@epa.gov]
From: BIO - Biotechnology Industry Organization
Sent: Thur 4/30/2015 7:15:36 PM
Subject: BIO Newsletter: April 30, 2015

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04.30.2015

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BIO INTERNATIONAL CONVENTION

Monday, June 15th Declared "BIO Superhero Day" in Philadelphia

Last week, Philadelphia Mayor Michael Nutter declared Monday, June 15th "BIO Superhero Day" in the City of Philadelphia in honor of the BIO International Convention's Everyday Superhero contest, which celebrates the contributions of the men and women of biotechnology who work tirelessly each day to heal, fuel and feed the world.

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GMOS

Skip the 1,000-Calorie Burrito and Chipotle's Dishonest Food Snobbery




At BIO, we support voluntary efforts to label GMO foods and any retailer's or restaurant's choice to source non-GMO ingredients as long as it's not done in a way that makes safety or health claims.

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21ST CENTURY CURES




BIO Praises the Release of 21st Century Cures Initiative Discussion Draft

BIO applaud the Committee on Energy and Commerce for releasing

its 21st Century Cures Initiative discussion draft intended to accelerate the discovery, development and delivery of next generation modern medicines...
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BIO INTERNATIONAL CONVENTION

Congrats to the 2015 Buzz of BIO Winners

We're very pleased to announce the winners for the 2015 Buzz of BIO contest of the BIO International Convention...
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HEALTH

The Power of Innovation

Fox and Friends included an informative segment about the staggering advances being made in cancer care thanks to new and forthcoming innovative treatments...
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HEALTH

BIO Principles on Expanded Access to Investigational, Unapproved Medicines

We believe that the best way to make innovative biotechnology medicines available to patients is through the efficient development of approved, safe and effective products...
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GMOS

Why the Founder of the Anti-GMO Movement Converted to the Side of Science

Lynas is a British environmentalist and author who once founded the movement against genetically modified foods in the mid 1990s...
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FOOD AND AGRICULTURE

Inventors of Life-Saving Golden Rice Receive Prestigious Patents for Humanitarian Award

On Monday, April 21, 2015, the White House Office of Science and Technology Policy and the U.S. Patent and Trademark Office announced the recipients of the 2015 Patents for Humanity Award...
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2015 BIO WORLD CONGRESS

2015 BIO World Congress to Showcase Canada's Industrial Biotech Industry

BIO has announced plenary and breakout session programs that will feature executives, industry experts and academics from Canada-based organizations, companies, and universities...

INTELLECTUAL PROPERTY

Statement Regarding the Introduction of Senate Patent Reform Legislation

BIO appreciates the good faith efforts of the co-sponsors of the PATENT Act...

Share:   

JOBS ACT

Biotech Leader Provides Testimony on Legislative Proposals to Enhance Capital Formation and Reduce Regulatory Burdens

The success of the Jumpstart Our Business Startups Act in the biotech industry means that the work of the Subcommittee on Capital Markets and Government Sponsored Enterprises has taken on increased importance for emerging biotech companies...

Share:   

HEALTH

April is Donate Life Month! Walk with the National Kidney Foundation on May 16!

The need for organ donations continues to increase in America. Of the over 123,600 Americans on the national organ transplant waitlist...

Share:   





06.15.15

2015 BIO International Convention

Join 15,000 global attendees at BIO 2015, June 15 – 18, 2015 in Philadelphia, PA for more than 29,000 one-on-one partnering meetings in 3 days. BIO's new One-on-One Partnering™ system will dramatically increase your ROI at the BIO International Convention and across all BIO partnering events. Combined with Inova's One-on-One Partnering™ Plus, the system will reduce your team's overall business development costs and will increase your partnering effectiveness year-round...

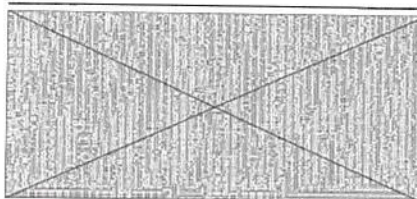
[LEARN MORE](#)

07.19.15

World Congress on Industrial Biotechnology

The BIO World Congress on Industrial Biotechnology is the world's largest industrial biotechnology event for business leaders, investors, and policy makers in biofuels, biobased products, and renewable chemicals...

REGISTER



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Berkeley, California, United States
April 14, 2015

Biostatistician, General Dynamics Information Technology- Military Health Services

Bethesda, Maryland, United States
March 23, 2015

Post-Doc, University of Rochester

Rochester, New York, United States
April 7, 2015

Research Associate - Mass Spectrometry, OncoPlex Diagnostics

Rockville, Maryland, United States
April 12, 2015

Sr. Regulatory Specialist, Biotech Center of Expertise, BASF Corporation

San Diego, California, United States
April 12, 2015

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To: Geoff Cooper[GCooper@ethanolrfa.org]; Farenback-Brateman, J H[j.h.farenback-brateman@exxonmobil.com]; Betty Taylor[btaylor@crcao.org]; Anderson, Jim [jander63@ford.com]; Camobreco, Vincent[Camobreco.Vincent@epa.gov]; De Kleine, Robert[RDEKLEIN@ford.com]; DeCicco, John[decicco@umich.edu]; Duffield, James[jduffield@oce.usda.gov]; Duffy, Jim[jduffy@arb.ca.gov]; Hamje, Heather[heather.hamje@concaawe.org]; hhogo@aqmd.gov[hhogo@aqmd.gov]; Kapur, Amit[Amit.Kapur@p66.com]; Larson, Robert[larson.robert@epa.gov]; Lax, David [lax@api.org]; Marelli, Luisa[luisa.marelli@jrc.ec.europa.eu]; Martin, Jeremy I.[JMartin@ucsusa.org]; McCormack, Derek[Derek.McCormack@NRCan-RNCan.gc.ca]; O'Grady, Devin[Devin.O'Grady@NRCan-RNCan.gc.ca]; Verduzco, Laura[laurav@chevron.com]; Wang, Michael Quanlu[mqwang@anl.gov]; Chris Tennant[ctennant@crcao.org]; Jan Tucker[Jantucker@crcao.org]; Brent Bailey[bkbailey@crcao.org]
From: Don Scott
Sent: Mon 4/27/2015 2:52:00 AM
Subject: RE: 2015 CRC Life Cycle Analysis Workshop Teleconference - Monday, Apr. 27 @ 11AM EDT/8AM PDT
Alberta ND & TX .pptx

Very interesting!

Attached are some images I plucked from Google Earth a couple months back. If you know where to look and how to toggle between the current mosaic and historical imagery in Google Earth, anyone can see the shocking increase in oil & gas activity. I pulled these examples together spending less than an hour total doing research, and with only a casual knowledge of where the big oil booms are happening. In fact, I was urged to do this, because my boss sees of lots of these well fields from the air when flying into DFW, and he wanted to know how many of them were new wells. A more complete inventory of these changes would be very fascinating.

The changes in Alberta are especially alarming. By default, Google Earth mosaics the images to look the prettiest with consistent color from tile to tile. If you click that off, you can see more recent images for some areas, and it is clear that the trees are being slashed along the Athabasca River faster than the photographs are being updated. The imagery was not nearly as good just a few short years ago; so some of the images before removal of the "overburden" are not as clear as newer images of strip mines that have taken their place. In just a few minutes of poking around, I found many strip pits that have been opened in recent years, and they are commonly as big as five miles in diameter. As you start training your eyes to interpret the Google Earth images, you can see a pattern in the Tiaga that existed in the forests that have now been cleared and also exists in vast stretches of forest surrounding the new open pits. I would be very curious to learn if that pattern was related to exploration, future overburden removal, or in-situ extraction. Like I said, I spent a very short time investigating, but it seems like some very major changes are going on.

Don Scott

Director of Sustainability

National Biodiesel Board

1-800-841-5849

From: Geoff Cooper [mailto:GCooper@ethanolrfa.org]

Sent: Sunday, April 26, 2015 8:49 PM

To: Farenback-Brateman, J H; Betty Taylor; Anderson, Jim ; Camobreco, Vincent; De Kleine, Robert; DeCicco, John; Duffield, James; Duffy, Jim; Hamje, Heather; Hogo, Henry ; Kapur, Amit; Larson, Robert; Lax, David ; Marelli, Luisa; Martin, Jeremy I.; McCormack, Derek; O'Grady, Devin; Don Scott; Verduzco, Laura; Wang, Michael Quanlu; Chris Tennant; Jan Tucker; Brent Bailey

Subject: RE: 2015 CRC Life Cycle Analysis Workshop Teleconference - Monday, Apr. 27 @ 11AM EDT/8AM PDT

All,

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Regar

Geoff

Geoff Cooper

Senior Vice President

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From: Farenback-Brateman, J H [<mailto:j.h.farenback-brateman@exxonmobil.com>]

Sent: Sunday, April 26, 2015 7:23 AM

To: Betty Taylor; Anderson, Jim ; Camobreco, Vincent; Geoff Cooper; De Kleine, Robert; DeCicco, John; Duffield, James; Duffy, Jim; Hamje, Heather; Hogo, Henry ; Kapur, Amit; Larson, Robert; Lax, David ; Marelli, Luisa; Martin, Jeremy I.; McCormack, Derek; O'Grady, Devin; Scott, Don; Verduzco, Laura; Wang, Michael Quanlu; Chris Tennant; Jan Tucker; Brent Bailey

Subject: RE: 2015 CRC Life Cycle Analysis Workshop Teleconference - Monday, Apr. 27 @ 11AM EDT/8AM PDT

To All:

In advance of the April 27 conference call, attached please find the draft minutes of the March 31 conference call, an updated version of the Straw Man Proposal, and a proposed agenda for tomorrow's call.

Jeff Farenback-Brateman

ExxonMobil Research & Engineering Co.

email: j.h.farenback-brateman@exxonmobil.com

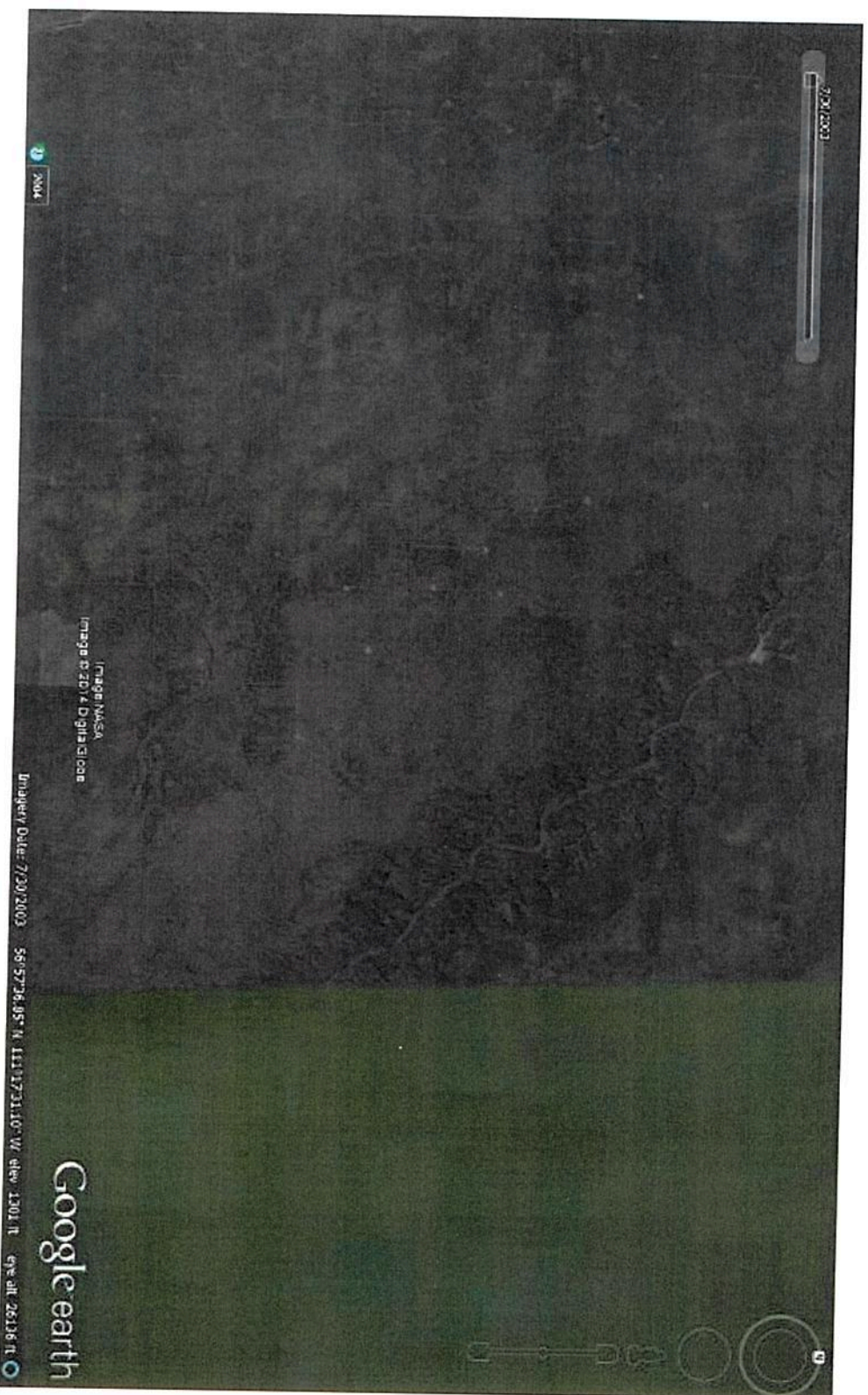
(856) 224-2036 (Office)

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(856) 628-5413 (Mobile)

(856) 224-3614 (FAX)

Boreal Forest near the Athabasca River 2003

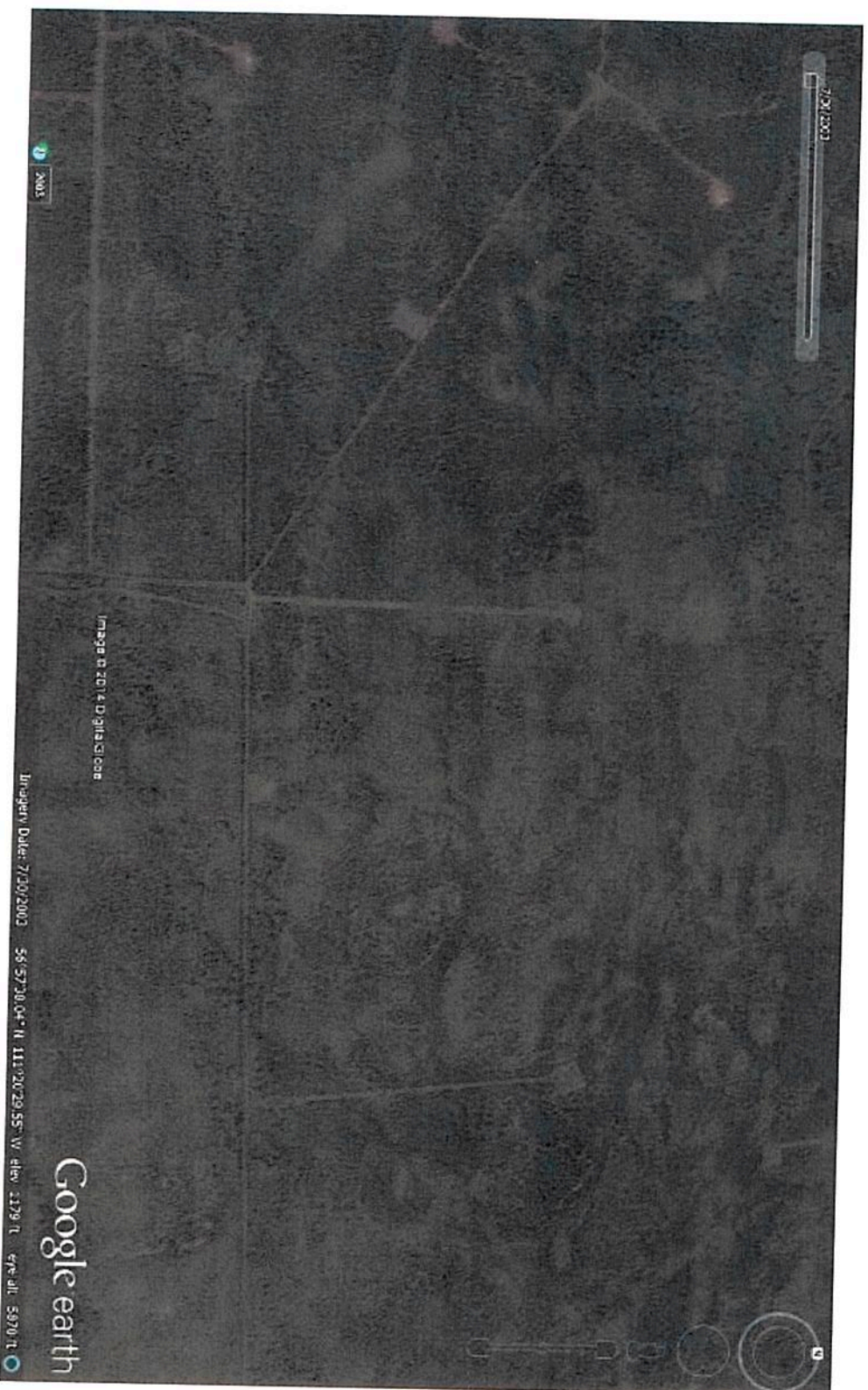


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0617



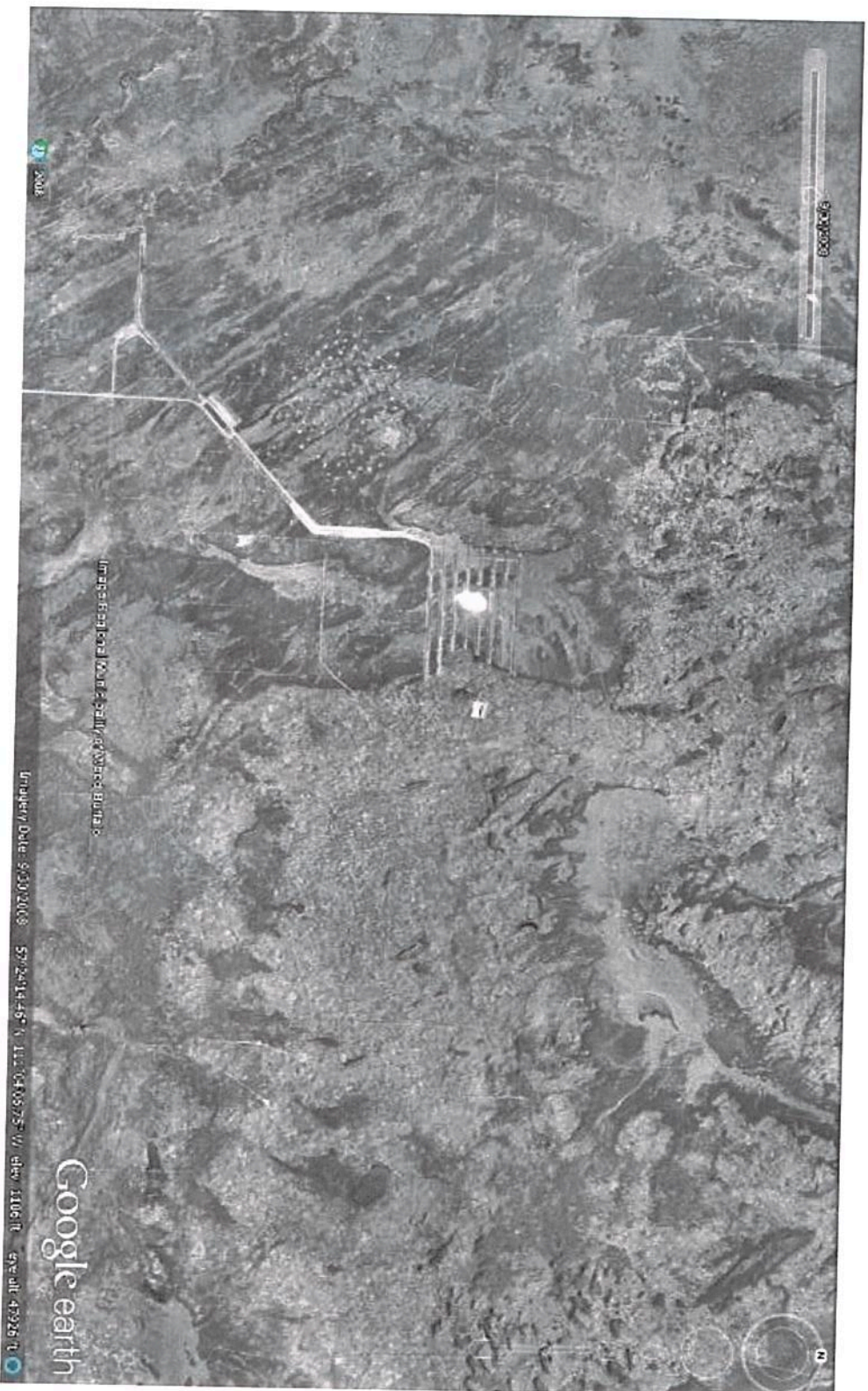
Boreal Forest near the Athabasca River 2003



Exact same view in 2012



Alberta 2008



APRIL 2013/2014

mosaic on right suggests that center photo is out of date, and that more trees have been removed.

0617



before



After



0617

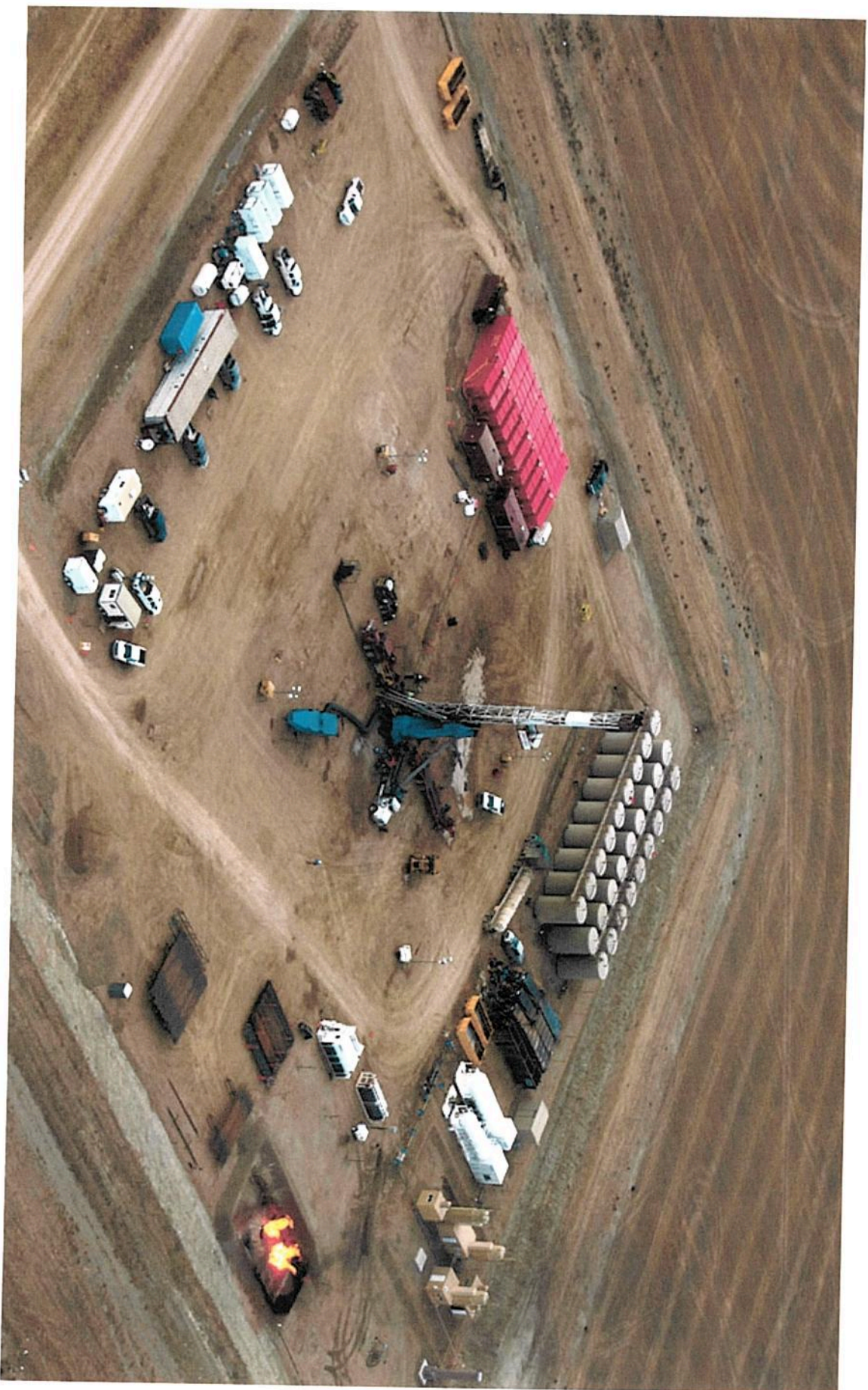
North Dakota Farm Land 2003



Same view 2014: Fracking wells, tank storage depot,
and surface pits mining aggregate for frack sites.



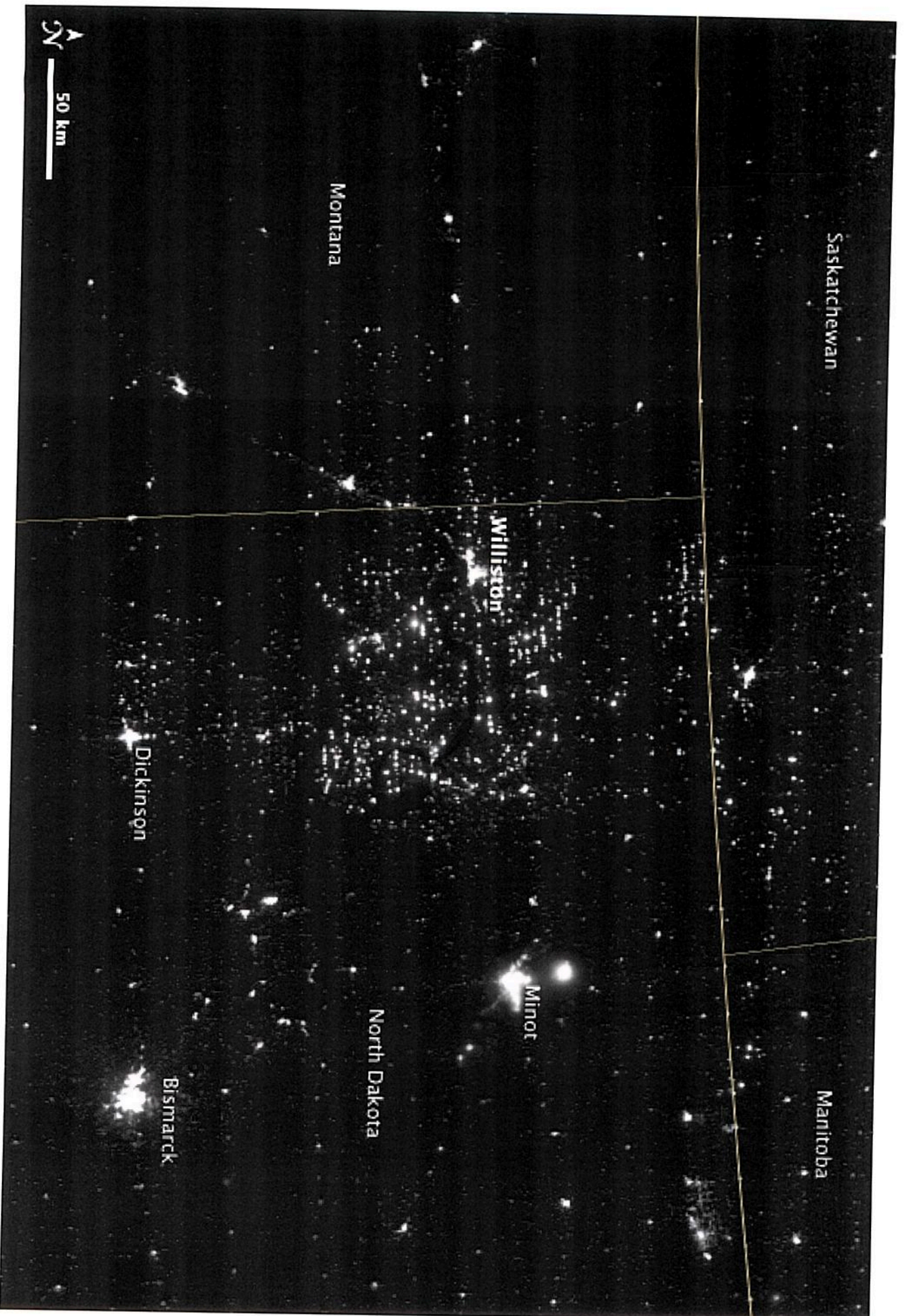
Oil Rig in North Dakota



Methane Flaring from Fracking



In their rush to extract oil, energy companies in North Dakota have burned off nearly a third of all the gas their wells have produced in recent years. By one estimate, that amounted to \$1 billion worth of gas in 2012, emitting the greenhouse gas equivalent of one million cars. Nicholas Kusnetz/Center for Public Integrity



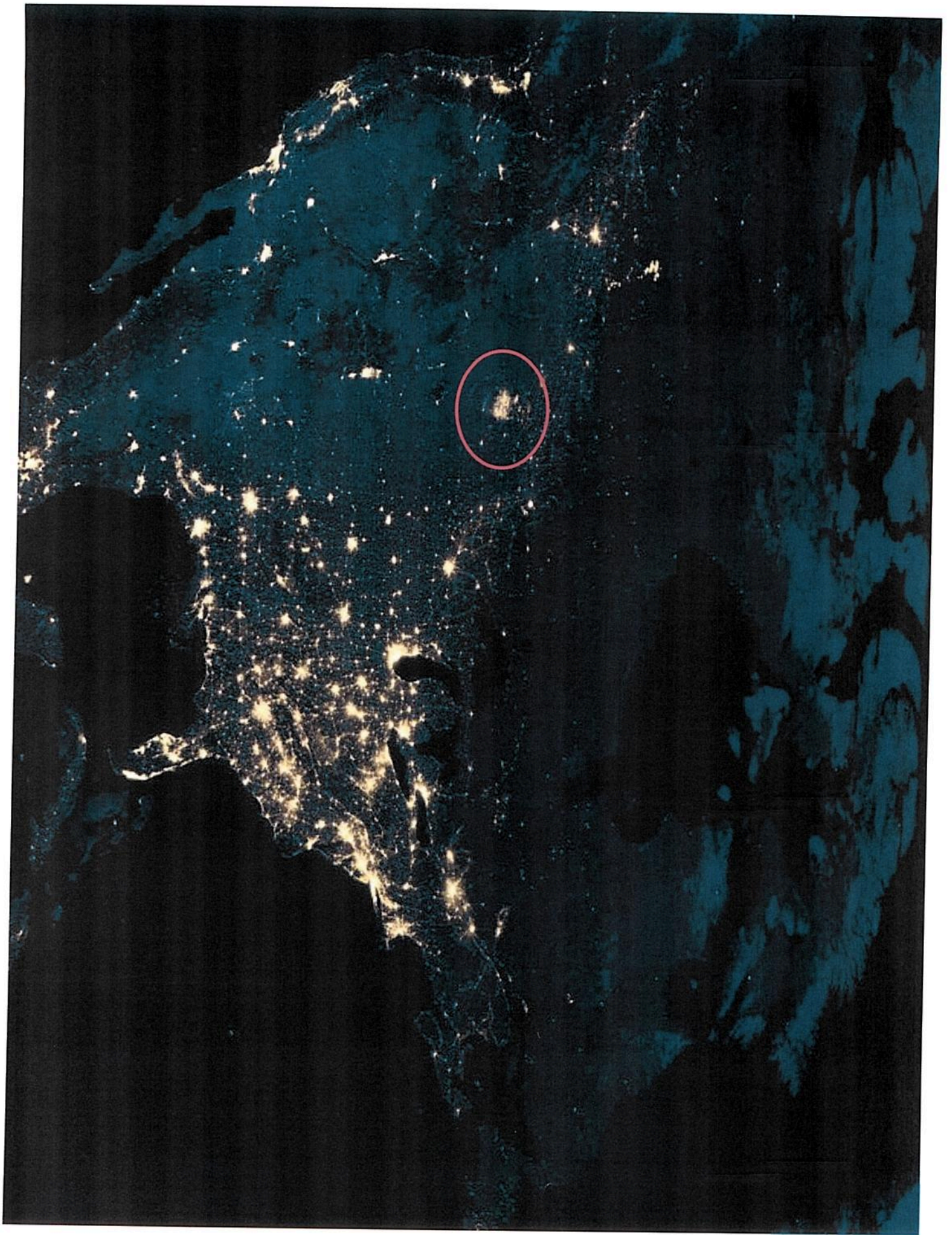
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0617



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Odessa, TX 2002



Odessa, TX 2014



Slaton, TX 2003



Slaton, TX 2014



To: Farenback-Brateman, J H[j.h.farenback-brateman@exxonmobil.com]; Betty Taylor[btaylor@crcao.org]; Anderson, Jim [jander63@ford.com]; Camobreco, Vincent[Camobreco.Vincent@epa.gov]; De Kleine, Robert[RDEKLEIN@ford.com]; DeCicco, John[decicco@umich.edu]; Duffield, James[jduffield@oce.usda.gov]; Duffy, Jim[jduffy@arb.ca.gov]; Hamje, Heather[heather.hamje@concaawe.org]; hhogo@aqmd.gov[hhogo@aqmd.gov]; Kapur, Amit[Amit.Kapur@p66.com]; Larson, Robert[larson.robert@epa.gov]; Lax, David [lax@api.org]; Marelli, Luisa[luisa.marelli@jrc.ec.europa.eu]; Martin, Jeremy I.[JMartin@ucsusa.org]; McCormack, Derek[Derek.McCormack@NRCan-RNCan.gc.ca]; O'Grady, Devin[Devin.O'Grady@NRCan-RNCan.gc.ca]; Scott, Don[DScott@biodiesel.org]; Verduzco, Laura[laurav@chevron.com]; Wang, Michael Quanlu[mqwang@anl.gov]; Chris Tennant[ctennant@crcao.org]; Jan Tucker[Jantucker@crcao.org]; Brent Bailey[bkbailey@crcao.org]

From: Geoff Cooper

Sent: Mon 4/27/2015 1:48:38 AM

Subject: RE: 2015 CRC Life Cycle Analysis Workshop Teleconference - Monday, Apr. 27 @ 11AM EDT/8AM PDT

[Allred et al 2015 Ecosystem services lost to oil and gas in N America -S....pdf](#)

All,

I will not be able to attend the call tomorrow, but I wanted to pass along the attached report published in Science Magazine last week. The study quantifies losses to NPP and land cover changes in the Great Plains region resulting from recent expansion of oil and gas operations. In particular, I thought the organizers of Session 4 (Advances in LCA of Petroleum/Alternatives) may possibly be interested in extending an invitation to the authors, as this appears to be a fairly novel and significant contribution to the literature.

Regards,

Geoff

Geoff Cooper

Senior Vice President

Renewable Fuels Association

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From: Farenback-Brateman, J H [mailto:j.h.farenback-brateman@exxonmobil.com]
Sent: Sunday, April 26, 2015 7:23 AM
To: Betty Taylor; Anderson, Jim ; Camobreco, Vincent; Geoff Cooper; De Kleine, Robert; DeCicco, John; Duffield, James; Duffy, Jim; Hamje, Heather; Hogo, Henry ; Kapur, Amit; Larson, Robert; Lax, David ; Marelli, Luisa; Martin, Jeremy I.; McCormack, Derek; O'Grady, Devin; Scott, Don; Verduzco, Laura; Wang, Michael Quanlu; Chris Tennant; Jan Tucker; Brent Bailey
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Jeff Farenback-Brateman

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ED_000313_O365_00000618

Ecosystem services lost to oil and gas in North America

Net primary production reduced in crop and rangelands

By Brady W. Allred,^{1,*} W. Kolby Smith,^{1,2}
Dirac Twidwell,³ Julia H. Haggerty,⁴
Steven W. Running,¹ David E. Naugle,¹
Samuel D. Fuhlendorf⁵

Advanced technologies in oil and gas extraction coupled with energy demand have encouraged an average of 50,000 new wells per year throughout central North America since 2000. Although similar to past trends (see the graph, this page), the space and infrastructure required for horizontal drilling and high-volume hydraulic fracturing are transforming millions of hectares of the Great Plains into industrialized landscapes, with drilling projected to continue (1, 2). Although this development brings economic benefits (3) and expectations of energy security, policy and regulation give little attention to trade-offs in the form of lost or degraded ecosystem services (4). It is the scale of this transformation that is important, as accumulating land degradation can result in continental impacts that are undetectable when focusing on any single region (5). With the impact of this transformation on natural systems and ecosystem services yet to be quantified at broad extents, decisions are being made with few data at hand (see the graph, this page).

We provide a first empirical analysis to advance beyond common rhetoric and speculation of oil and gas development (6), combining high-resolution satellite data of vegetation dynamics with industry data and publicly available data of historical and present-day oil and gas well locations for central North America. In addition to this broad-scale assessment of satellite-derived net primary production (NPP), a fundamental measure of a region's ability to provide ecosystem services (7), we also evaluate patterns of land-use change and

water use. Before this work, little has been done in examining these types of data and their relations with ecosystem services at broad scales.

ECOSYSTEM SERVICE TRADE-OFFS. NPP is the amount of carbon fixed by plants and accumulated as biomass. It is a fundamental and supporting ecosystem service that is the basis for all life on Earth (8). As such, the dynamics of NPP affect regional ability to provide a host of other essential ecosystem services (e.g., food production, biodiversity, wildlife habitat), which makes it a robust metric for broad evaluation of ecosystem services. Oil and gas activity reduces NPP through direct removal of vegetation to construct oil pads, roads, and so on.

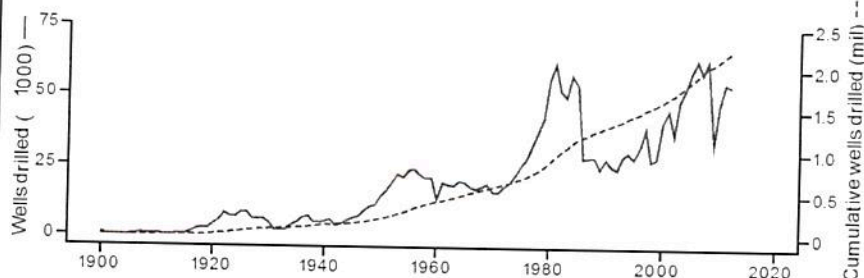
These satellite-derived measurements of

of carbon per year, we convert to equivalent biomass-based measurements to provide context and discussion.

We estimate that vegetation removal by oil and gas development from 2000 to 2012 reduced NPP by ~4.5 Tg of carbon or 10 Tg of dry biomass across central North America (see the chart on page 402, left). The total amount lost in rangelands is the equivalent of approximately five million animal unit months (AUM; the amount of forage required for one animal for 1 month), which is more than half of annual available grazing on public lands managed by the U.S. Bureau of Land Management (BLM). The amount of biomass lost in croplands is the equivalent of 120.2 million bushels of wheat, ~6% of the wheat produced in 2013 within the region and 13% of the wheat exported by the United States (see SM for equivalency calculations).

The loss of NPP is likely long-lasting and potentially permanent, as recovery or reclamation of previously drilled land has not kept pace with accelerated drilling (SM). This is not surprising because current reclamation practices vary by land ownership and governing body, target only limited portions of the energy landscape, require

Oil and gas wells drilled in central Canada and USA



The number of oil and gas wells drilled within central provinces of Canada and central U.S. states 1900–2012. Canadian provinces: Alberta, Manitoba, and Saskatchewan. U.S. states: Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming. See SM.

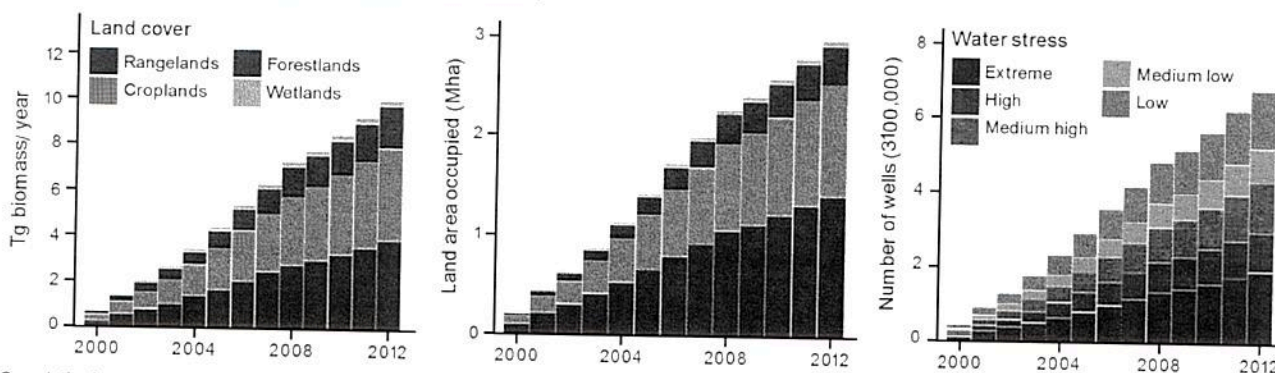
NPP began in 2000 and are produced annually; they capture interannual dynamics (9). To match the spatial scale of NPP measurement (~1 km²), we determined annual density of oil and gas activity at the same resolution and estimated annual loss of NPP relative to such densities. Direct loss of vegetation resulting from oil and gas activity was validated at medium and fine spatial scales (~250 m² and 30 m², respectively) by examining vegetation and disturbance trends before and after drilling [see supplementary materials (SM)]. We categorized annual reductions in NPP relative to land cover type (e.g., cropland and rangeland). As NPP is measured in grams

substantial funding and implementation commitments, and are often not initiated until the end of life of a well (10). Barring changes from existing trends and practices, it is likely that NPP loss and its effects (i.e., further loss of forage) will continue to parallel drilling trends and, potentially, may create unforeseen conflicts among agriculture, conservation, and energy.

Additional ecosystem functions, including wildlife habitat and landscape connectivity, are arguably as important as NPP. We estimate that the land area occupied by well pads, roads, and storage facilities built from 2000 to 2012 is ~3 million ha, the equivalent land area of three Yellowstone

¹College of Forestry and Conservation, University of Montana, Missoula, MT 59812, USA. ²Institute on the Environment, University of Minnesota, St. Paul, MN 55108, USA. ³Department of Agronomy and Horticulture, University of Nebraska—Lincoln, Lincoln, NE 68583, USA. ⁴Department of Earth Sciences, Montana State University, Bozeman, MT 59717, USA. ⁵Department of Natural Resources Ecology and Management, Oklahoma State University, Stillwater, OK 74078, USA. *Corresponding author: brady.allred@umontana.edu

Oil and gas development impacts on ecosystem services



Cumulative impacts of oil and gas development on ecosystem services in central North America 2000–2012. (Left) Reduction in NPP (biomass), per land cover type. (Middle) Land area occupied, per land cover type. (Right) Number of wells in water-stressed regions (22). See SM.

National Parks (see the chart, middle). Although small in comparison with the total land area of the continent, this important land use is not accounted for (11) and creates additional pressures for conserving rangelands and their ecosystem functions. The distribution of this land area has negative impacts: increasing fragmentation that can sever migratory pathways, alter wildlife behavior and mortality, and increase susceptibility to ecologically disruptive invasive species (6, 12). As competition for arable land intensifies because of food and bioenergy demand (13), oil and gas may further expand into native rangelands.

The hydraulic fracturing technology underlying the current expansion of oil and gas drilling in the region has profound implications for hydrological, water-quality, and water-use regimes. High-volume hydraulic fracturing uses 8000 to 50,000 m³ of water per well for the initial fracturing event (14), which results in 7187 to 33,903 million m³ for wells drilled across this region during 2000 to 2012 (see SM). Nearly half of wells drilled in this time period occurred in already highly or extremely water-stressed regions (see the chart, right). As refracturing becomes more common to yield greater production, oil and gas development adds to an already fraught competition among agriculture, aquatic ecosystems, and municipalities for water resources, in addition to concerns of water quality (15).

AVOIDING BROAD-SCALE LOSS. The capacity for insight into land-use decisions has improved substantially since the last major episode of widespread land-use change across the Great Plains. In the early 20th century, rapid agricultural expansion and widespread displacement of native vegetation reduced the resilience of the region to drought, ul-

timately contributing to the Dust Bowl of the 1930s. It took catastrophic disruption of livelihoods and economies to trigger policy reforms that addressed environmental and social risks of land-use change.

Fortunately, data and information are now far less of a barrier in understanding and addressing continental and cumulative impacts. However, the scale and focus of most land-use decision-making discourages comprehensive assessment of trade-offs implied in oil and gas development (16, 17). Recent planning efforts by U.S. federal management agencies demonstrate potential to balance demand for energy development with the need to protect other values (18, 19), but the scope is limited to lands under federal jurisdiction. About 90% of oil and gas infrastructure in this region occurs on private land (United States only; see SM). Provinces, states, and municipalities that permit the majority of oil and gas development lack the capacity and mandate to address continental or regional consequences that transcend political boundaries; this lack leads to fragmented and piecemeal policies (16, 20).

Decision-makers and scientists must work together to ensure that the best available information guides development of policies at the water-energy-food nexus (21). Traditional laws and regulations may have limited application, as oil and gas can be exempt from key environmental regulations (20), or such regulations isolate features of systems—e.g., a single species—while failing to capture interrelated impacts. Active synthesis and consolidation of data will improve accessibility and monitoring. Integration of these data into land-use planning and policy across scales and jurisdictions is necessary to achieve energy policies that minimize ecosystem service losses.

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ACKNOWLEDGMENTS

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SUPPLEMENTARY MATERIALS

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


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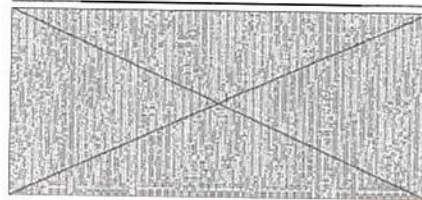
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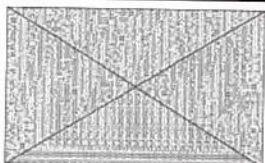
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Algae InSight

Edition: March 23, 2015

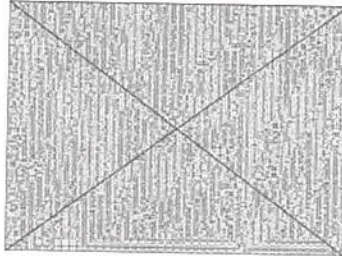
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Executive Director's Report



Each year the Algae Biomass Organization surveys its members and industry experts on their expectations for the future of algae biomass and related products. This year we heard from more than 230 people in all corners of the industry and found surprisingly strong -- and broad -- optimism about the coming commercialization of a new wave of technologies.

Overall, there are three key takeaways from the data:

- There is broad agreement that algae fuels, feeds, plastics and other products are likely to be price competitive with incumbent products within the decade, if not sooner. Some are price competitive already.
- Production of algal biomass and associated products as well as hiring across departments is expected to increase in both the short and the long term.
- Supportive and consistent federal policies will further accelerate production and hiring.

I encourage you to check out our [full executive summary and accompanying side deck at ABO's website.](#)

One figure that jumped out to me was that 91 percent of algal fuel producers felt that they could get prices below \$5.00 per gallon by 2020.

That may seem like an uncompetitive price now, but if the recent drop in oil prices proves anything it is that what we pay at the pump can change remarkably fast. I think the \$5.00 mark will be very close to price competitiveness in 2020, and that ultimately it will be the downward trend of algae prices that gets the interest of big players in the fuel markets. After all, fossil oil reserves will only diminish, while biomass from algae keeps on growing.

Along the way to algae fuels we will see a number of algae-derived products carving out space in feed, nutrition and industrial markets. Optimism for these products was highest of all in our survey, and is quite understandable-many of them, such as Omega-3 supplements, are already available to consumers.

The arrival of these products underscores one final point in our survey. When we asked about policy priorities survey

respondents ranked regulatory approvals for algae-derived products and siting of cultivation or production facilities among the most important.

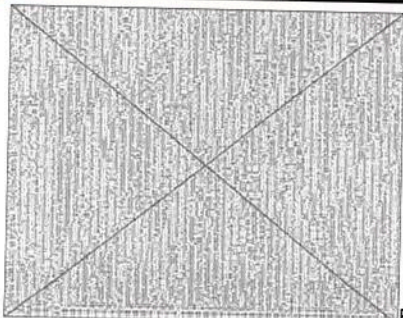
When a new industry's latest plans are focused on getting products to market you know that commercialization is moving ahead at full speed.

Despite what you might hear about low gas prices upsetting the economic order, or policy dysfunction in Congress, I see a bright future for algae.

Matt Carr

Executive Director
Algae Biomass Organization

Reserve Your Exhibit Space at the 2015 Algae Biomass Summit



Booth spaces on the exhibit floor of the 2015 Algae Biomass Summit are now on sale. The exhibit floor at the Summit is the best place to showcase your algae-derived products, new technologies, research and business services.

This is the one time of year that the entire industry gets together under one roof -- don't miss out. Reserve your spot today!

Details are available at the Summit website.

USDA Expands Investments in Next-Generation Bioenergy Development

The U.S. Department of Agriculture has announced the availability of up to \$8.7 million in funding for bioenergy research and education efforts, as well as publishing the final rule for a program that provides incentives for farmers and forest landowners interested in growing and harvesting biomass

NETL Announces Funding Opportunity for Algae Industry on CO2 Utilization

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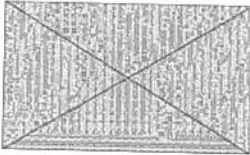
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As we continue to promote the development of commercial markets for sustainable products derived from algae, we invite you to join us in our efforts by becoming a member of the Algae Biomass Organization. As the trade association for the industry, we act as a voice for the industry to the public, media and policy makers while also representing individuals and companies across the value chain. As an ABO member, you'll have access to a wide range of services and information, including:

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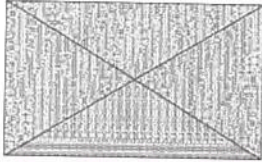
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Algae InSight

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Executive Director's Report

Why bioenergy with carbon capture, utilization and storage?
BECCUS.

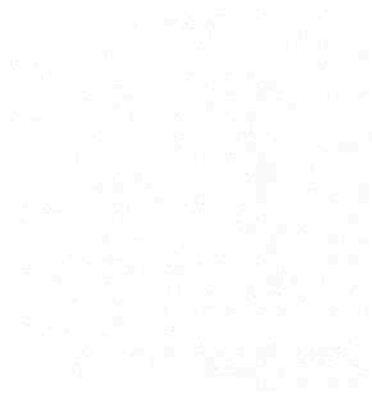
In a [paper](#) published earlier this month, researchers at the University of California, Berkeley, find that biomass power generation, when combined with carbon capture and sequestration (CCS), is a potential negative carbon power source. Because plants remove CO₂ from the atmosphere during growth, capture and underground storage of CO₂ from biomass combustion can result in net reductions of atmospheric CO₂ concentrations. This bioenergy with carbon capture and sequestration (BECCS) approach, the authors conclude, could be a key strategy to mitigating climate change.

The authors have it almost right. Capturing carbon from combustion of biogenic carbon does indeed provide a double carbon benefit to the atmosphere. But the best bang for the buck is delivered when, as in the case of algae-based carbon capture and utilization (CCU), that captured carbon is reused to produce yet more energy that substitutes for fossil fuels.

Such a bioenergy with carbon capture and utilization approach (which I here christen BECCU) is a triple play for climate, absorbing carbon upstream, avoiding emissions at the power plant, and keeping fossil carbon stored for all time by substituting algae-based alternatives for fossil-derived fuels. It's a AAA-rated approach! And, unlike underground storage, BECCU comes with a strong business case: revenue generated from carbon utilization can help offset, or even negate, the cost of carbon capture.

In the case of algae-based CCU, there is even the added potential for co-production of new sources of proteins, plastics, and a host of other valuable products, further enhancing both the environmental and economic sustainability of the system.

We need look no further than the corn fields of Iowa to see BECCU in action - though in a slightly different form. BioProcess Algae's [project](#) with Green Plains, Inc., in Shenandoah, Iowa, shows just how carbon- (and cash-) efficient energy systems can be with BECCU. In capturing biogenic carbon from the corn ethanol fermentation process, BioProcess and Green Plains deliver the same climate triple play as in the power plant scenario while enhancing the economics and environmental profile of corn ethanol



production.

Granted, there may be some scenarios where underground storage is still the best available option. So, let's go with an all-encompassing net negative carbon acronym. Why bioenergy with carbon capture, utilization and storage? BECCUS.

Matt Carr
Executive Director
Algae Biomass Organization

Call for Abstracts - 2015 Algae Biomass Summit

The Algae Biomass Organization is now accepting abstracts and proposals for the 2015 Algae Biomass Summit, being held in Washington, DC, September 30-October 2. Submit your own proposals for keynote speakers, panel presentations and poster sessions at the event, the world's largest algae industry conference.

Speaking opportunities for the Summit are highly competitive, making the submission of high-quality abstracts before the **March 16, 2015 deadline** essential.

Submit your abstracts at <http://www.algaebiomasssummit.org/?page=Abstracts>.

NETL Announces Funding Opportunity for Algae Industry on CO2 Utilization

The National Energy Technology Laboratory (NETL) has recently added algae to an existing funding opportunity announcement (FOA) aimed at R&D for "Transformational Carbon Dioxide Capture Technologies for Coal-Fired Power Plants." The funding opportunity was amended to insert a new area of interest: Area of Interest 4 - Biological CO2 Use/Conversion, and the FOA specifically states, "For the purpose of this solicitation, biological use/conversion applications should be limited to aquatic species, such as microalgae and blue-green algae (cyanobacteria)."

This is significant policy advancement for the algae industry and one that ABO has been actively pushing. We applaud NETL for their interest in algae as a means of utilizing CO2. We anticipate that DOE's Fossil Energy office will use the industry's response to this solicitation to gauge whether they should make future investments in algae as a means of reducing CO2 in the atmosphere, so we strongly encourage interested parties to respond - the March 9 deadline for submissions is rapidly approaching.

You can find the full documentation for this opportunity on FedConnect.net:

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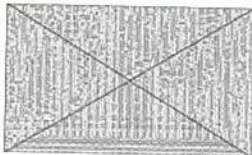
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- Regular industry updates and issue alerts via member-only communications;
- Opportunity to participate in ABO committees;
- Results from our annual industry survey;
- Access and input to the ABO's Technical Standards documents;
- Participation in members-only events, webinars, briefings and networking opportunities;
- Discounted registration for ABO-hosted industry events.

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17th Annual BIO CEO & Investor Conference to Feature Congressional Leaders, Institutional Investors, Industry Analysts and Senior Biotechnology Executives




BIO announces Business Roundtables, Plenary Sessions and Therapeutic Workshops selected for the 17th annual BIO CEO & Investor Conference...

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HEALTH

BIO President and CEO to Keynote Opening Session of the Texas Healthcare and Bioscience Summit




BIO President and CEO Jim Greenwood will serve as opening keynote speaker for the second annual Texas Healthcare and Bioscience Summit...

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HEALTH

BIO Responds To President Obama's State of the Union Speech

"Biotech holds the greatest promise for finding a cure. Precision medicine – finding the right treatment for the right patient at the right time – can help maximize clinical benefit while reducing the risk of side effects."

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ANIMAL BIOTECHNOLOGY

GE Mosquitos May Be on Their Way to the Florida Keys

The GE Mosquito made its debut when it was first introduced in Brazil to help fight Dengue Fever...

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ANIMAL BIOTECHNOLOGY

Genetically Modified Cattle With Human DNA Might Hold Ebola Cure

Maggie Fox reported for NBC news on exciting research taking place in Sioux Falls, S.D. to combat the Ebola virus with the help of genetically modified cattle...

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FOOD AND AGRICULTURE

GM Sugar Beet Has Shown to Save Growers Millions

The adoption of Roundup Ready sugar beets is saving Idaho and Eastern Oregon growers an estimated \$22 million a year...

FOOD LABELING

AP Poll Shows Support for GMO Labeling Lessens

New AP poll finds 66 percent of Americans back GMO labeling — far lower than the 93 percent in the 2013 New York Times Poll, Mary Clare Jalonick of the Associated Press...

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GMO ANSWERS

GMO Basics: Why Uncertainty is Part of Science?

GMO Answers posted a great excerpt from a recent SenseAboutScience publication which explores why uncertainty is a natural occurrence in the field of science and how scientists deal with it...

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of 02-09-2015



02.09.15

BIO CEO & Investor Conference

The BIO CEO & Investor Conference is the largest investor conference focused on established and emerging publicly traded and select private biotech companies. Because our mission is to support industry-wide success, we present a broad and unbiased view of investment opportunities...

REGISTER

03.09.15

BIO-Europe Spring®

BIO-Europe Spring® continues the tradition of providing life science companies with high caliber partnering opportunities. Join us March 9-11 in Paris, France...

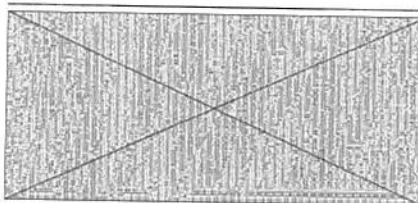
SAVE THE DATE

03.24.15

BIO Asia International Conference

The BIO Asia International Conference, co-hosted by the Biotechnology Industry Organization (BIO), BioCentury Publications and the Japan Bioindustry Association (JBA), brings together the global biotechnology and pharmaceutical industry to explore licensing and research collaborations in the current Asia-Pacific business and policy environments...

SAVE THE DATE



Associate Manager,
Manufacturing API
PFN, BAYER

Berkeley, California, United States
January 25, 2015

Director, California
Institute for Regenerative
Medicine

San Francisco, California, United States
January 7, 2015

CMC Project Manager/Sr.
CMC Project Manager,
CMC Biologics

Seattle, Washington, United States
January 12, 2015

Senior Engineer,
Mechanical/Chemical,
Genentech

South San Francisco, California, United States
January 15, 2015

Vice Chancellor for Research,
Innovation and Economic
Development, NC State
University

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